RCA

# HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. XVII No. 4  DECEMBER, 1957

# HAM SHACK TROUBLE-SHOOTER

## Solve Your Operations Problems with the Versatile RCA VoltOhmyst

**By Rhys Samuel, W2GOQ**

**RCA Electron Tube Division, Harrison, N. J.**

> This feature is Part I of a two-part article covering the use of vacuum-tube voltmeters in the ham shack. Hams everywhere are finding the VTVM an indispensable tool because of the variety and wide range of measurements which can be made with these versatile and accurate instruments.

To the amateur who has used an RCA *VoltOhmyst®* for routine checking and trouble-shooting in his ham shack, the vacuum-tube voltmeter has become the first rival of the soldering iron.

VoltOhmysts* are useful in dozens of trouble-shooting applications in receivers, frequency meters, variable-frequency and crystal oscillators, exciter units, power amplifiers, power supplies of all sizes, and speech amplifiers and modulators. Factory construction and calibration on all functions and ranges against precise laboratory standards make the VoltOhmysts exceptionally dependable.

These instruments have an input resistance of 11 megohms on all dc-voltage ranges, making possible precise voltage measurements in power supplies which have limited current-drain characteristics.

VoltOhmysts are versatile measuring devices. The RCA WV-98A Senior VoltOhmyst, for example, can measure—in seven ranges—dc voltages up to 1500 volts, ac voltages up to 1500 volts rms (4200 v p-p), and resistance values up to 1000 megohms. When used with the WG-289 high-voltage probe, RCA VoltOhmysts can measure dc voltages up to 50 Kv. When the accessory WG-301A crystal-diode probe is used, rf measurements can be made up to 250 Mc. Because these instruments read resistance values up to 1000 megohms, they are invaluable in checking equipment for leaky capacitors and other high-resistance shorts which might not be detected with ordinary low-range ohmmeters.

### Voltage Measurements

Before making any voltage measurements, always connect the ground cable of the VoltOhmyst to the equipment ground point. Greatest accuracy will be obtained when the scale which gives a reading nearest the full-scale point is used.

All of the VoltOhmysts are equipped with a single switch-type probe and cable for measuring both ac and dc voltages and resistances. For dc-voltage measurements, set the switch to "DC." It is now possible to make dc-voltage measurements in circuits which also contain an ac signal. This feature is valuable when trouble-shooting receivers and low-power exciter stages.

Set the switch to the "AC/Ohms" position for ac-voltage and resistance measurements.

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### Resistance Measurements

The first rule to observe in making resistance measurements is to *remove all power from the circuit being tested.* Failure to observe this precaution may result in damage to the test instrument. It is also advisable to discharge all capacitors in the circuit under test to prevent their residual charge from adversely affecting the meter reading. The accuracy of the resistance measurement can be increased by using the scale which provides a reading nearest the centerscale point on the meter.

In a complex electronic circuit, shunt-circuit resistance may be difficult to determine. In such cases, it will be necessary to unsolder individual components or to disconnect major leads or buses before resistance measurements are made.

### Measurements in RF Fields

Strong rf fields in transmitters may affect the meter measurement of either ac or dc voltages. In making such measurements in the presence of rf, always connect the VoltOhmyst ground cable to a point near the test point. If an auxiliary rf probe is used, ground the short lead on the probe as near as possible to the test point. If the rf field still upsets the meter reading, move the instrument to another position and re-orient the test leads.

The WG-301A crystal-diode probe (see inset of Figure 1) is a slip-on type which attaches to the front end of the WG-299C dc/ac-ohms probe and cable, and provides for the measurement of rf voltages up to 250 Mc. The WG-301A can be used to check relative signal levels in receiver oscillators and low-power exciter stages. With this probe combination, it is not usually possible to measure the rf-signal voltages in power oscillators and amplifiers because the peak values of such voltages are relatively high. Before making rf measurements, make sure that estimated signal voltage values do not exceed the input-voltage ratings of the probe.

### Bias Measurements

Bias-voltage measurements are important in transmitter stages inasmuch as the bias level determines the class of operation of the stage and greatly affects the drive requirements, power output, and harmonic content. Depending upon the class of amplifier, bias is adjusted to a cutoff or beyond cutoff value. In class C amplifiers utilizing fixed bias, the bias is adjusted so that no plate current flows when excitation is removed. Under class $AB_1$, $AB_2$, and B conditions, however, some plate current will flow under key-up conditions. For plate-modulated class C operation, bias is customarily increased to approximately two and one-half times the amount required for plate-current cutoff.

Some of the typical arrangements used to obtain grid bias are shown in Figure 2. In all arrangements, except that of Figure 2-F, the chassis (ground) is the reference point because the cathodes are grounded. Read the bias on the "—DC VOLTS" scales of the VoltOhmyst. In the illustrations, the operating bias ($E_{op}$) is the total amount of bias supplied or developed under driving conditions. Fixed or protective bias ($E_{pr}$) is used in the circuits shown in Figures 2-B, 2-C, 2-D, and 2-E. The operating bias in these circuits is made up of the total of the amount of fixed bias plus the bias developed when grid current flows through the grid resistor, if used. In all of the above illustrations, total bias is measured between point X in the grid circuit and the chassis.

Not all grid-circuit arrangements in transmitters contain an rf choke or rf bypass capacitor, and the accuracy of the bias measurement under key-down conditions will depend upon the amount of driving power and VTVM stability under rf conditions.

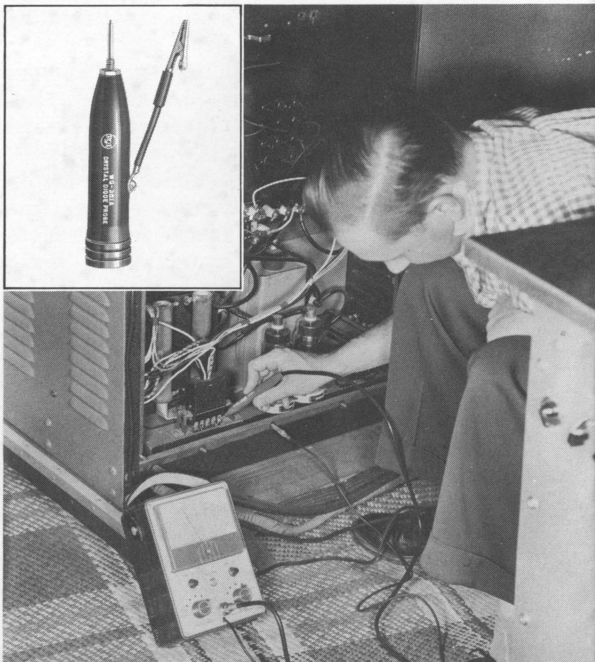

Figure 1. W2IYG uses WV-77C Junior VoltOhmyst with the WG-299C probe and cable to measure 400 volts for driver stage of his 800-watt transmitter. The WV-77C when used with the WG-299C has an input resistance of 11 megohms on all ranges, and will measure voltages up to 1200 v dc. Inset shows WG-301A crystal diode probe for measuring rf voltages up to 250 Mc. The WG-301A slips over the front end of the WG-299C.

### High-Voltage Measurements

The maximum dc-voltage limit of the RCA WV-77C VoltOhmyst is 1200 v; for the WV-87B and WV-98A, 1500 v. To amateurs, the high-voltage probe can quickly become an indispensable measurement accessory. When making high-voltage measurements, first remove all B+ voltages from the transmitter. Next, with probe and ground cable properly connected to the VoltOhmyst, connect the ground clip of the probe to the transmitter chassis. Then, connect the tip of the probe to the high-voltage test point. If measurements and circuit adjustments are to be made simultaneously, clamp or tape the probe tip firmly in position. Next, make sure the VoltOhmyst is set up for plus dc-voltage measurements and that a suitable voltage range is selected. Apply plate voltage, screen voltage, and grid drive to the amplifier. Because the high-voltage probe attenuates the input voltage by a factor of 100, multiply the meter reading by 100 to obtain the true voltage measurement.

The voltage regulation of the power supply may be determined by measuring its output voltage under two conditions: (1) with no excitation applied to the amplifier without load and (2) with excitation applied to the amplifier with load. The percent change in output voltage between zero load and load is the voltage regulation. As the load increases, the output voltage will tend to decrease.

The plate power input to the amplifier stage can be determined simply by multiplying the plate voltage as read on the meter scale by the total amount of plate current in amperes drawn from the supply.

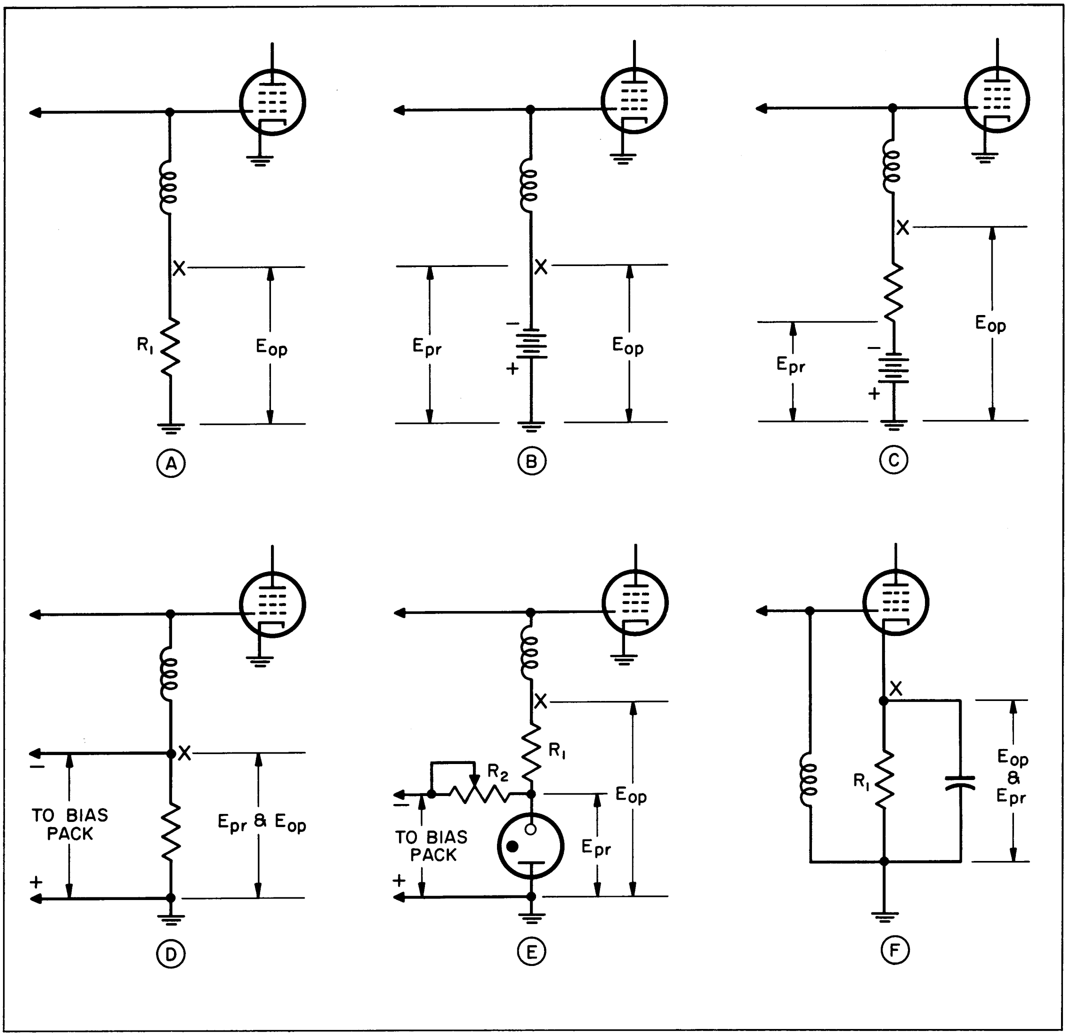


Figure 2. Typical arrangements used to obtain grid bias.

RCA

From your local RCA distributor, headquarters for RCA receiving and power tubes.

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## Here's an *Automatic* Tube Tester for the Shack

The "test-it-yourself" ham is going to be interested in the new RCA WT-110A *Automatic* Electron-Tube Tester which was recently announced and is now available from your local RCA distributor. The WT-110A is capable of testing a wide variety of receiving-type tubes used in amateur transmitters, receivers, and test instruments. The new tube tester will check interelectrode shorts and leakage, gas condition, and general quality.

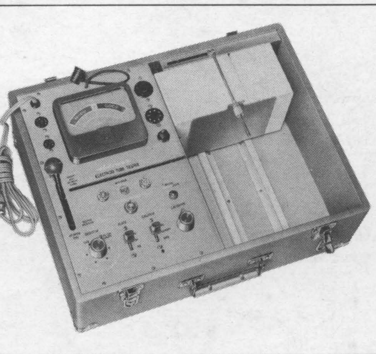
General quality testing is based on measurement of the transconductance of the tube. Readings are provided in terms of "Renew—?—Good" on a 4½-inch meter. The gas condition is also indicated on the meter.

Tube-pin and test voltage connections are automatically set up in the WT-110A by inserting individual pre-punched computer-type information cards in a slot on the front panel of the instrument. There is a separate card for each tube type.

The new tester comes supplied with a set of 239 of these pre-punched cards for 7-pin and 9-pin miniature, octal-, and lock-in-type receiving tubes. Unpunched cards and a punch are available as accessories to enable the amateur to make his own test cards.

The pre-punched card system used in the WT-110A accommodates the popular receiving tube types employed in communications, broadcast and TV receivers, including diodes, triodes, tetrodes, pentodes, and multiunit receiving tubes which have similar and dissimilar units.

In addition, the WT-110A has special provision for making high-resistance interelectrode leakage and low-value gas-current tests on certain tube types. These special tests make possible a better evaluation of tube types used in applications critical to leakage or gas.



# HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION


VOL. XVIII, No. 1  FEBRUARY,1958

# HAM SHACK TROUBLE-SHOOTER

## Practical Applications of the Versatile RCA VoltOhmyst


**by Rhys Samuel, W2GOQ**

**RCA Electron Tube Division, Harrison, N. J.**


This feature concludes the two-part article covering the use of vacuum-tube voltmeters in the ham shack and covers a few of the many applications in which *VoltOhmysts*® can be used. The examples shown below serve to illustrate the measurement principles and techniques utilized for specific equipment, but they can be applied, in general, to similar types of equipment.

### Checking Oscillators

The VoltOhmyst* can be used to check all operating voltages under key-up or key-down conditions in both types of oscillator circuits shown in Figure 1. The measurement principles involved in these representative circuits can be applied to any type of oscillator.

A complete check of the operating voltages includes measurement of ac heater voltage, control-grid voltage, screen-grid voltage, and plate voltage. To measure the heater voltage, connect the ground cable to the chassis (ground) if one end of the heater supply is grounded, or to one side of the heater and connect the probe to the other side of the heater. Always make heater-voltage measurements directly at the tube pins. Faulty solder connections or IR drop in heater-lead wiring can cause insufficient voltage at the tube socket, although normal voltage can be measured at the transformer.

In tetrode and pentode oscillators, screen voltage influences overall performance of the stage. In keyed oscillators, measure the plate and screen voltages under both key-up and key-down conditions. Unless a voltage-regulated power supply is used, the key-down voltage will be less than the key-up voltage.

If the oscillator delivers much power, measure the plate voltage at point D in either of the circuits of Figure 1, rather than at point E, to prevent the strong rf signal from affecting the voltage reading. The capacitor from point D to ground serves to keep rf energy from getting into the supply lead and permits the measurement to be made. Because no dropping resistor is used in the plate circuit, the dc voltage measured at point D should be the same as at point E. Plate current will increase with off-resonance tuning and cause a change in the dc voltage at the tube.

Measure the screen voltage at point C, which is at rf ground potential because of the screen bypass capacitor, If a considerable amount of power is being drawn from the oscillator, make sure that screen voltage does not exceed the permissible rating for the tube when the key is up. The degree of voltage change under keying depends upon power-supply regulation.

The amount of developed grid bias is a good indication of how the stage is function-

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ing; the amount of bias voltage will increase with the strength of oscillation. The dc probe can be used to check bias at point A. This voltage is negative with respect to the cathode and is measured between the control grid and cathode of the oscillator stage. Bias will decrease as the plate load is increased.

### Amplifier and Multiplier Stages

It is equally important that the operating voltages of amplifier and frequency-multiplier stages be set correctly to prevent damage to tubes and to minimize generation of harmonics and parasitics. The typical amplifier stages shown in Figure 2 differ in their input-coupling arrangements and plate-feed methods. Plate-circuit tuning in both these amplifiers will affect the grid, screen, and plate-current flow and will generally affect the voltage levels at the tube. The bias voltage measured at point A in both circuits, for example, will depend upon the amount of drive and, in triode amplifiers, upon plate-circuit tuning. Grid-circuit tuning will also affect the amount of measured bias. Bias voltage will increase with excitation and will be greatest at grid-circuit resonance.

In amplifier stages, measure operating voltages under both key-up and key-down conditions. If an appreciable amount of current is drawn by the amplifier tube, the plate, screen, and bias voltages can change over a relatively wide range. Under these conditions, it is important to prevent the screen voltage from rising to a value which exceeds the screen-dissipation rating of the tube, especially in circuit 2B. The VoltOhmyst can be used to measure the dc voltages at points C in both circuits under key-up and key-down conditions.

DC-voltage measurements at point A will provide an exact indication of the total bias. Plate voltages should be measured at point D in the circuit. Because different amplifier arrangements utilize different types of bias circuits, no single method of measuring bias will suffice for all arrangements.

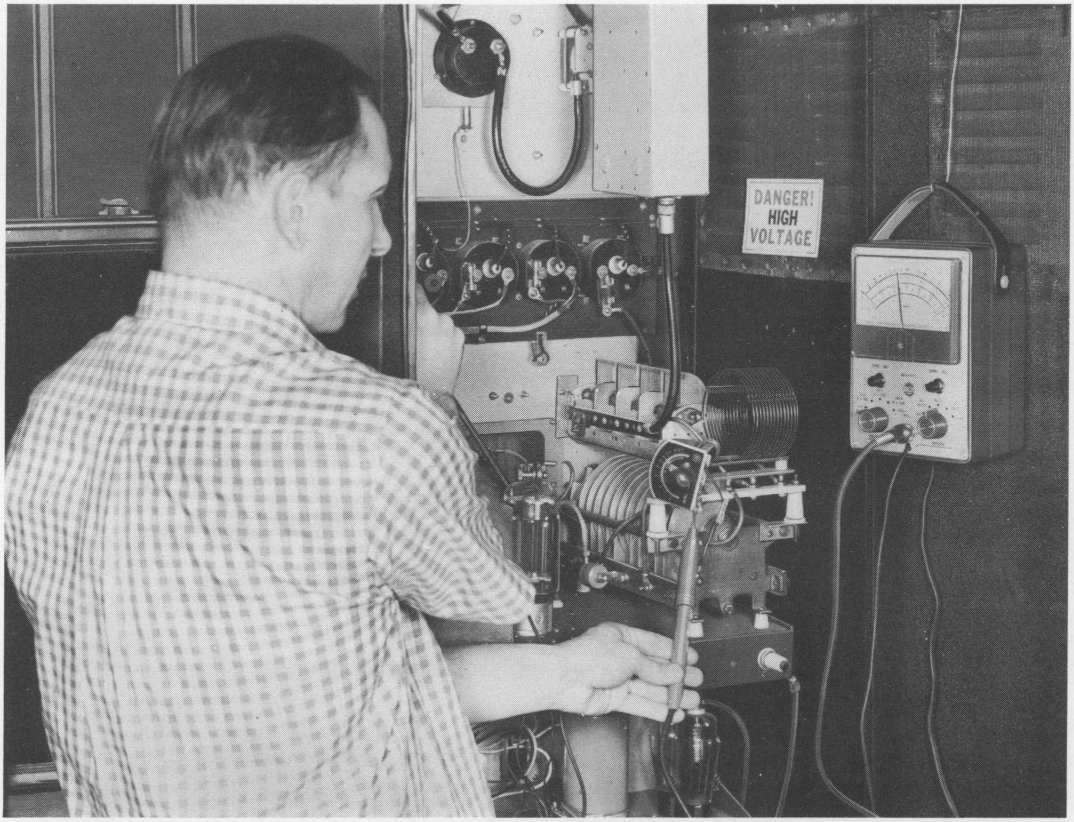
### Adjustment of High-Power Amplifiers

Measurement of operating voltages in high-power amplifiers deserves special consideration for several reasons. For example, the high plate and screen voltages employed are hazardous, and measurement techniques must take into account the possibility that high voltages may appear at unexpected points because of insulation breakdown in the transmitter. Also, misadjustment of tuning controls or operating voltages may damage costly tubes and components, especially when newly constructed equipment is first tested.

While the transmitter circuit shown in Figure 3 may differ considerably in design from those found in many ham rigs, the measurement techniques and precautions described for it apply to all transmitter amplifiers. In all high-power equipment, checking and adjustment of ac filament voltages is especially important to tube life and performance. Grid-bias voltages are equally important because they have a direct effect upon the screen and plate dissipation of the tube under key-up conditions. The value of the grid-bias voltage also affects drive requirements and sets the operating level (class of operation) of the amplifier. In tetrodes, screen voltages should be carefully adjusted to insure that screen dissipation is kept within proper limits under both key-up and key-down conditions. Plate voltages, as well as plate current, should be determined exactly when the operating level borders on the legal input-power limit or the maximum permissible ratings for the tube type.

### Preliminary Checks

In setting up an rf amplifier for the first time, use the VoltOhmyst to make precautionary measurements before applying plate and screen voltages. When checking out a high-power amplifier, such as that shown in Figure 3, use the following procedure: (1) Apply filament and grid-bias voltages. Remove excitation. (2) Set up the VoltOhmyst for ac-voltage measurements. Check the filament voltage of each tube directly at the filament pins (xx) and (yy) by connecting the ground cable to one pin and the ac probe to the other pin at the same tube socket. Filament voltage should be within at least ±5% of the recommended voltage for the tube type. (3) If the voltage measured at either filament is off by more than ±5%, measure the line voltage on the primary side of the filament transformers. If line voltage is correct, IR drop in the filament wiring may be responsible. In this event, replace the wiring with heavier conductors. It is also possible that one of the filament transformers may need replacement because of improper turns ratio. (4) Check the fixed grid bias by setting up the VoltOhmyst for "—DC" voltage measurements and read the voltage directly at the grid pins of both tubes. This is a wise precaution, especially in equipment which is not protected against grid-bias failure. If proper voltage is measured for both tubes, the wiring is correct and the fixed-bias supply is functioning properly.




When connected to a wavemeter circuit, the VoltOhmyst makes an excellent rf-tuning indicator. Here, W2IYG uses the WV-77C and WG-301A Crystal-Diode Probe during neutralizing of final amplifier.

The separate bias-supply leads feeding the two halves of the grid circuit in Figure 3 are provided as a means of checking the balance of the push-pull circuit. Do not attempt to measure total grid voltage at the grid pins when excitation is applied because of the high rf grid voltage. (5) Adjust the grid-tank tuning and the coupling to obtain the required amount of grid current in both grid-circuit legs. Remove excitation. (6) The amplifier can now be checked for plate-current cutoff or, if it is to be operated class AB or B, for the required amount of static plate current. With fixed bias applied and excitation removed, apply plate and screen voltages. Note the plate current flow, if any, and adjust the bias voltage from the supply to give the required cutoff or static current. Remove the high voltage. (7) The plate and screen circuits can now be checked with excitation applied and with the amplifier under dummy load. In circuits which employ high-perveance tubes, take care to prevent excessive plate and screen current flow while tuning. Unless dial settings of plate-tank resonant points are first established by means of a grid-dip oscillator, use a considerably reduced plate voltage for tuning. Measure the plate voltage at point C and the screen voltage at point D. The rf choke and capacitor C5 will keep rf out of the VoltOhmyst at point D. Point C is likewise at rf ground potential because of the rf choke and bypass capacitor.

The basic measurement procedures just described should provide a thorough and reliable check of equipment operating conditions and adjustments. When voltage measurements indicate improper operation or component failure, the VoltOhmyst can be set up quickly for resistance measurements and for conventional trouble-shooting.

### Miscellaneous Applications

The filtering action of power-supply filters may be determined easily by measuring the ac component at the output of the filter. The VoltOhmysts are well suited to this application because of their ability to measure ac in the presence of dc voltages.

Ripple is measured by setting up the VoltOhmyst for ac-voltage measurements on a

low-range scale, connecting the ground cable to the negative side of the power-supply filter section, and connecting the probe to the positive side. Figure 4 shows the setup and a representation of the ripple and dc components of the output voltage. The VoltOhmyst will indicate only the rms value of the ripple component.

The effectiveness of the filter can be expressed in terms of percent of ripple, which is the ratio of the rms value of the ripple voltage to the value of the dc voltage multiplied by 100. For example, if the dc voltage is 250 v and the measured ripple voltage is 1.25 v, the percentage of ripple is 0.5.

Power-supply regulation can be determined simply by measuring the dc output voltage under load ($E_{minimum}$) and no-load ($E_{maximum}$) conditions. Percentage of regulation is equal to:

$$\frac{E_{maximum} - E_{minimum}}{E_{maximum}} \times 100$$

### Neutralization Indicator

When used in conjunction with the WG-301A crystal-diode probe, the VoltOhmyst can be employed as a neutralizing indicator in power-amplifier stages. Amplifier neutralization is normally accomplished with plate voltage removed and with excitation applied. If the amplifier is not properly neutralized, some rf energy will appear in the plate-tank circuit. Proper adjustment of the neutralizing capacitors in the amplifier will eliminate the rf from the plate circuit.

A neutralizing setup which employs the VoltOhmyst as an rf indicator is shown in Figure 5. Set the VoltOhmyst to its lowest dc-voltage range and attach a small wire loop to the tip of the WG-301A probe. Make sure the amplifier plate voltage is off. Couple the loop tightly to the plate-tank coil. Apply excitation and tune the plate-tank capacitor near the resonant point until a reading is obtained on the VoltOhmyst. Adjust the neutralizing capacitors equally until no reading or a minimum reading is obtained on the VoltOhmyst. It is usually necessary to retune slightly to maintain a reading on the VoltOhmyst because adjustment of the neutralizing capacitors changes the tuning point at which the rf indication occurs.

### Wavemeter—Field-Strength Meter

The VoltOhmyst and WG-301A probe can also be used in combination with a tuned circuit as a wavemeter and field-strength meter, as shown in Figure 6. This arrangement is especially useful in determining the frequency of an output signal, in checking for radiation from transmitters, and in plotting the radiation patterns of antenna systems.

The tuned circuit consists simply of a coil and capacitor which can be adjusted to the operating frequency. The coil is tapped about one-third of the length along its turns. Set up the VoltOhmyst on its lowest dc-voltage scale and connect the WG-301A crystal-diode probe to the coil tap. Adjust the tuned circuit for maximum reading on the meter. It may be necessary to experiment somewhat with the length of the pick-up lead used on the wavemeter to obtain a suitable meter indication. In these applications, the readings obtained will be relative but useful, nevertheless, in making adjustments and checks.

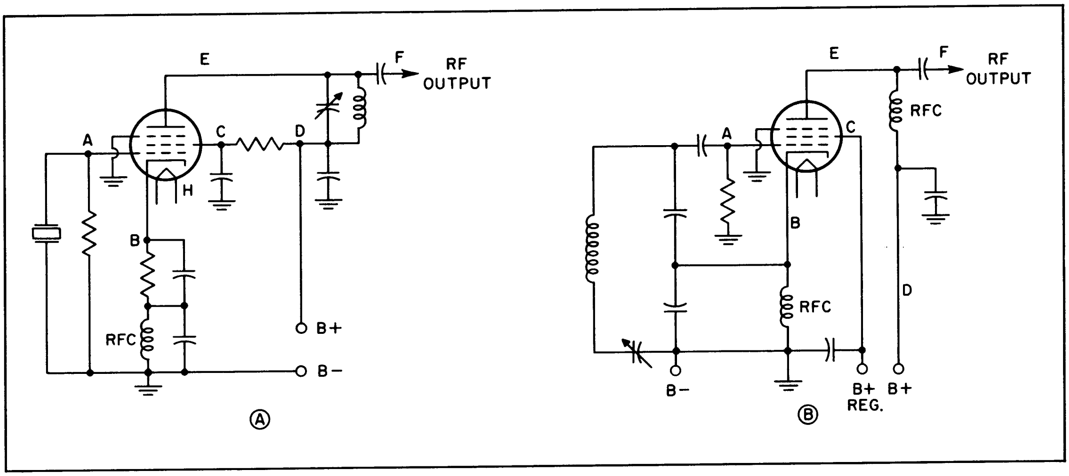



Figure 1. Typical oscillator circuits.

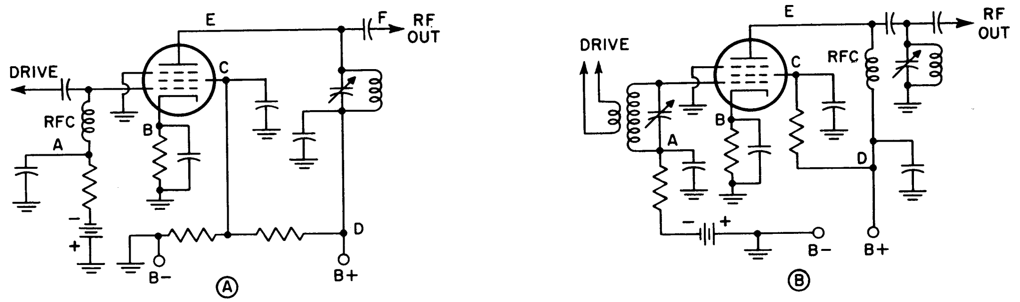



Figure 2. Typical amplifier stages.

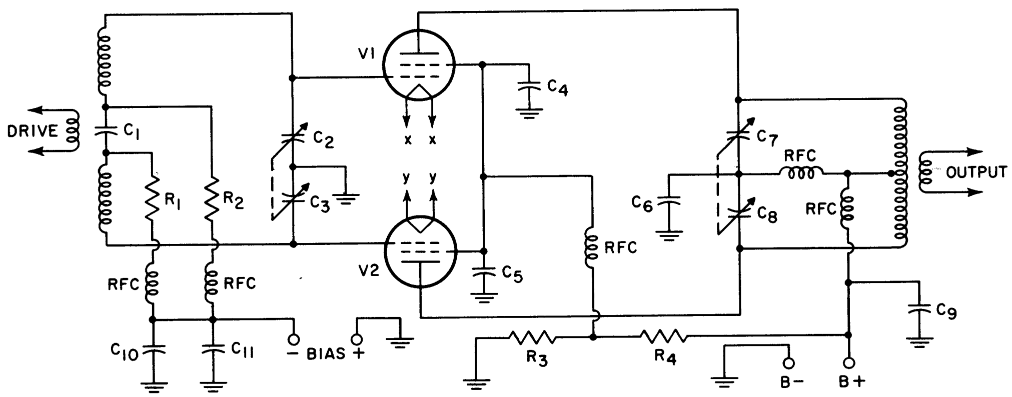



Figure 3. A transmitter final amplifier circuit.

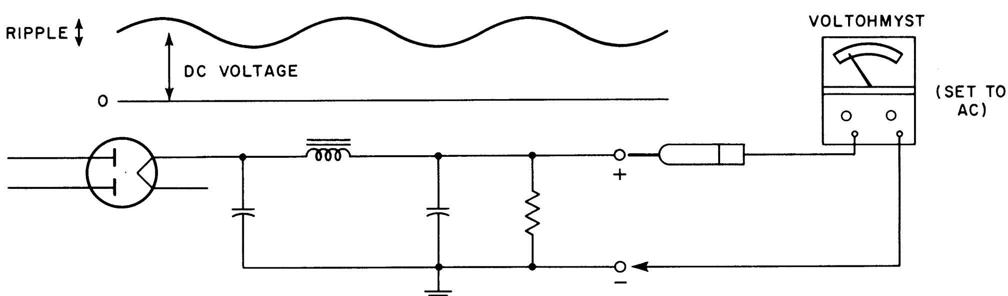



Figure 4. Measuring ripple voltage in PS output.

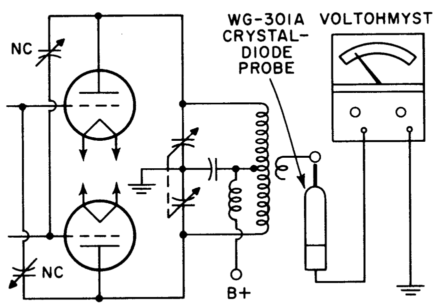



Figure 5. Neutralization of final amplifiers.

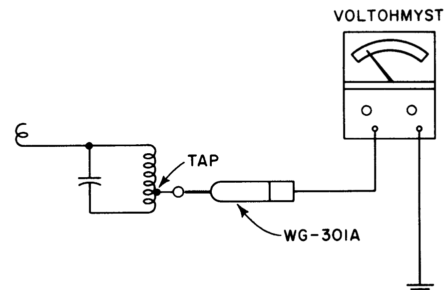


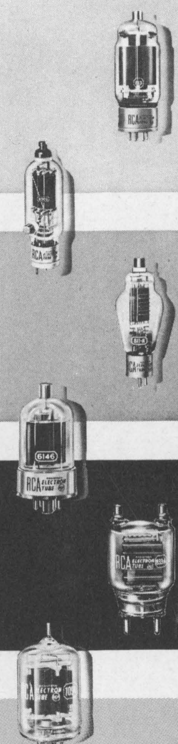

Figure 6. The VoltOhmyst used as a wavemeter.

### RCA Tubes for Linear RF Power Amplifier Service (Single-Sideband, Suppressed Carrier)

(Arranged according to Power Output)

| RCA Type | Class of Operation | Max. Frequency for full Input Mc | Heater (H) or Filament Volts | Typical Operating Conditions (Per Tube): DC Plate Volts | DC Grid-No. 2 Volts | DC Grid-No. 1 Volts | Peak RF Grid-No. 1 Signal Volts | Zero-Signal DC Plate Current Ma. | Max. Signal DC Plate Current Ma. | Approx. Max.-Sig. Driving Power Watts | Effective Load Resistance Ohms | Approx. Max.-Sig. Power Output Watts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6CL6 | AB1 | 60 | 6.3(H) | 300● | 150 | −6 | 6 | 4.6 | 16 | 0 | 9100 | 3 |
| 6973 | AB1 | 60 | 6.3(H) | 400 | 250 | −24 | 24 | 8.4 | 33 | 0 | 5600 | 9 |
| 2E24 | AB1 | 125 | 6.3 | 500 | 210 | −21 | 21 | 10 | 35 | 0 | 8300 | 11 |
| 1614 | AB1 | 80 | 6.3(H) | 450 | 300 | −35 | 35 | 14 | 50 | 0 | 5000 | 16 |
| 2E26<br>6893 | AB1<br>AB1 | 125<br>125 | 6.3(H)<br>12.6(H) | 500 | 210 | −30 | 30 | 9 | 53 | 0 | 5370 | 17 |
| 837 | B | 20 | 12.6(H) | 500 | 0# | 0# | 40 | 2.6 | 61 | 3.5 | 4630 | 21 |
| 807 | AB1 | 60 | 6.3(H) | 750 | 300 | −35 | 35 | 15 | 71 | 0 | 6250 | 35 |
| 1625 | AB1 | 60 | 12.6(H) | 750 | 300 | −35 | 35 | 15 | 71 | 0 | 6250 | 35 |
| 6816 | AB1 | 60 | 6.3(H) | 850 | 300 | −15 | 15 | 40 | 100 | 0 | 3500 | 40 |
| 6524■<br>6850■ | AB1<br>AB1 | 100<br>100 | 6.3(H)<br>12.6(H) | 600 | 300 | −33.5 | 67† | 30▲ | 122 | 0 | 12100‡ | 50 |
| 6146<br>6883 | AB1<br>AB1 | 60<br>60 | 6.3(H)<br>12.6(H) | 750 | 180 | −46 | 46 | 12 | 98 | 0 | 4640 | 52 |
| 809 | B | 60 | 6.3 | 700 | — | 0 | 72 | 35 | 118 | 8 | 3900 | 59 |
| 829-B■ | AB1 | 200 | 6.3(H)<br>12.6(H) | 750 | 225 | −25 | 50† | 20▲ | 132▲ | 0 | 13640‡ | 68▲ |
| 805 | B | 30 | 10.0 | 1250 | — | 0 | 110 | 78 | 204 | 3.5 | 3560 | 155 |
| 828 | AB1 | 30 | 10.0 | 2000* | 750 | −115 | 95 | 25 | 116 | 0 | 10300 | 157 |
| 4X150A | AB1 | 500 | 6.0(H) | 1250 | 300 | −50 | 50 | 57 | 202 | 0 | 3500 | 157 |
| 811-A | B | 30 | 6.3 | 1500 | — | 0 | 85 | 13 | 150 | 13 | 6260 | 160 |
| 813 | B | 30 | 10.0 | 2500 | # | 0# | 91 | 30 | 133 | 12 | 11000 | 219 |
| 6161 | B | 900 | 6.3(H) | 1600 | — | −57 | 82 | 80 | 239 | 18 | 3720 | 225 |
| 813 | AB1 | 30 | 10.0 | 2500● | 750 | −95 | 90 | 25 | 148 | 0 | 9660 | 245 |
| 7094 | AB1 | 60 | 6.3(H) | 2000 | 400 | −50 | 44 | 30 | 200 | 0 | 6000 | 280 |
| 7034 | AB1 | 150 | 6.0(H) | 2000 | 300 | −48 | 48 | 60 | 250 | 0 | 4270 | 290 |
| 833-A | B | 30 | 10.0 | 3000 | — | −70 | 165 | 50 | 328 | 5 | 5600 | 700 |

■ Twin Type
▲ Total Value per tube in Push-Pull application
† Grid No. 1 to Grid No. 1 Signal
# With Grids Nos. 1, 2 & 3 tied together at socket
* With −60 Volts on Grid No. 3
● With Grid No. 3 Tied to Filament Supply Center Tap
‡ Effective plate-to-plate value



# How to put your finger on the right tube for SSB!

The *right* RCA Tube for your single-sideband amplifier is listed in this chart. For the power you want, simply read down the column on the right. For the corresponding RCA Tube type, read the column on the left. When you make your choice—let the Typical Operating Conditions be your guide.

Known for their big reserve of cathode emission, RCA Tubes meet the requirements for single-sideband transmission—to the letter. And they have the power sensitivity it takes to build a signal up to full power in one stage—from low input signals. When you go SSB...any power from a few watts to the limit ...remember, you can do it better *with RCA Tubes.* They are available at your RCA Tube distributor.

**RADIO CORPORATION OF AMERICA**
***Electron Tube Division*** ***Harrison, N. J.***



From your local RCA distributor, headquarters for RCA receiving and power tubes.

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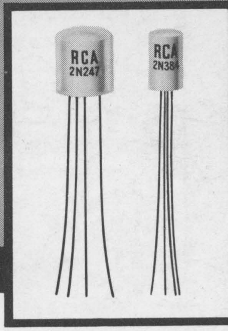
# HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. XVIII, No. 2


APRIL, 1958




# A TRANSISTORIZED GRID-DIP METER


**By Clarence A. West, W21YG**

**RCA Electron Tube Division, Harrison, N. J.**

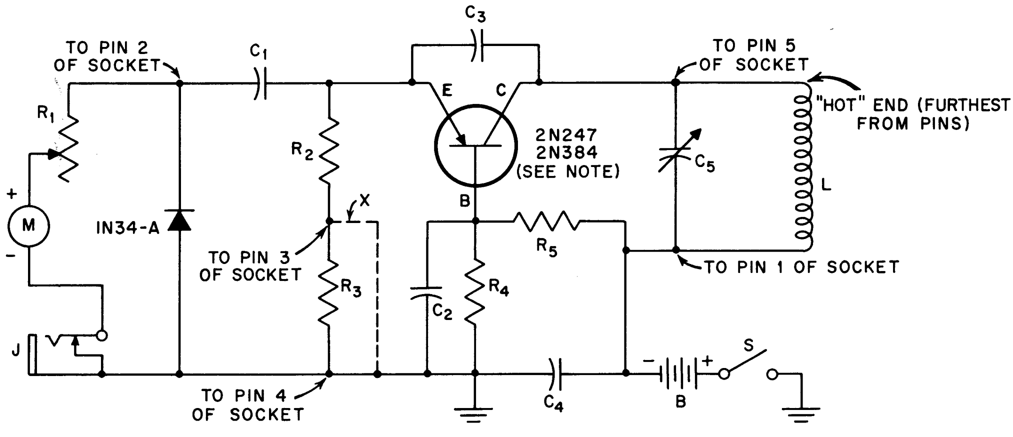

Like the VTVM, the grid-dip meter has become an important instrument, actually a necessity, for all serious-minded designers and builders of multiband communications equipment. In view of the fact that valuable tubes in a power amplifier can be ruined by operation of the amplifier with a plate tank circuit incapable of resonance, a grid-dip meter is inexpensive insurance. Because this instrument can also be used for other applications such as a wavemeter, signal generator, or field strength meter, an up-to-date amateur station can hardly afford to be without one.

Part I of W21YG's two-part article, beginning in this issue, contains a description of the grid-dip meter designed and constructed by the author, along with details of its construction. A schematic diagram and parts list, as well as close-up views of the instrument, are also featured.

Instructions on the operation and use of this grid-dip meter will be given in Part II.

**The transistorized grid-dip meter described in this article measures only 2 1/8 by 3 by 5 1/4 inches. It can be held and operated with one hand.**

Basically, a grid-dip meter consists of an rf oscillator capable of being tuned over a wide frequency range, a visual indicator to show when energy is being absorbed from the oscillator tank circuit, and a source of power. Practically all grid-dip meters utilize an electron tube in the oscillator circuit with a low-range milliammeter or microammeter connected to read grid current. Their most common use is to determine the resonant frequency of de-energized tuned circuits. The grid-dip meter described in this article utilizes a high-frequency drift transistor (RCA type 2N247 or 2N384) in the oscillator circuit, a semiconductor diode (RCA type 1N34-A) and microammeter as an rf indicator, and a 13½ volt miniature battery, such as the RCA-VS304, as the source of power. Oscillation in the common-base oscillator circuit is sustained by the feedback capacitor $C_3$ (see Figure 1). Rf voltage in the emitter-base circuit is capacitively coupled through $C_1$ to a semiconductor diode, and the rectified output can be read on the dc microammeter M. When power is absorbed from




B—13½-volt battery (RCA-VS304)
$C_1$—33 uuf, mica, 150 volts
$C_2$—0.01 uf, paper, 150 volts
$C_3$—5 uuf, mica, 150 volts
$C_4$—0.01 uf, paper, 150 volts
$C_5$—50 uuf variable (Hammarlund HF-50)
J—Phone jack, normally closed
L—Plug-in coil (see coil-winding chart)
M—0-50 microammeter (Simpson Model 1227)
$R_1$—0.25 megohm, variable, 0.5 watt
$R_2$—220 ohms, 0.5 watt
$R_3$—3000 ohms, 0.5 watt
$R_4$—3900 ohms, 0.5 watt
$R_5$—39,000 ohms, 0.5 watt
X—Jumper to set emitter voltage: pins 3 and 4 of coils above 45 Mc (see text)

**COIL-WINDING CHART**

| *Coil* | *Freq. Range* | *Wire Size* | *No. of Turns* |
|---|---|---|---|
| 1 | 3.4-6.9 Mc | #28, enamel | 48¼, close wound* |
| 2 | 6.7-13.5 Mc | #24, enamel | 22, close wound |
| 3 | 13-27 Mc | #24, enamel | 9⅛, close wound |
| 4 | 25-47 Mc | #24, enamel | 4⅛, close wound |
| 5 | 45-78 Mc | #24, enamel | 1½, close wound |
| 6 | 74-97 Mc | #16, tinned | Hairpin formed, 1⅞ inches long, including pins, and ¼ inch wide |

***All coil forms are Amphenol type 24-5H. For utmost in dial accuracy turns may be spread or compressed slightly before spraying.**

**Figure 1: Schematic diagram, parts list, and coil table. Note that the 2N384 is for use at frequencies up through 100 Mc; the 2N247 for use at frequencies up through 50 Mc (including 6-meter band). The interlead shield is grounded.**

the tuned circuit, L and $C_5$, rf feedback to the emitter is reduced and the microammeter shows a decreased reading. Some damping of the indicator circuit is provided by the emitter resistors $R_2$ and $R_3$.

Three desirable features for such an instrument are compactness, portability, and a self-contained power source. The low power drain and small size of the transistor used has enabled the instrument described in this article to have all of these features.

Measuring only 2⅛ by 3 by 5¼ inches, this grid-dip meter can be held and operated with one hand. It is compact and, therefore, capable of being closely coupled to tuned circuits in compactly designed equipment. It is completely portable and, being battery-operated, can be used anywhere. Because there is no heater to warm up, the instrument is instant-starting. Also due to the absence of heat, its frequency stability is excellent. Total power consumption is about 25 milliwatts! The instrument is relatively shock-resistant, and requires little maintenance. The transistor itself may never require replacement. The battery drain is so small that, with normal use, battery life for all practical purposes is "shelf life." Equally important, the instrument is very sensitive and accurate.

The RCA drift transistors, 2N247 and

2N384, are ideal for use in this instrument because they are designed specially for high-frequency applications. The 2N384 produces useful output in the circuit shown in Figure 1 at frequencies up through 100 megacycles. The 2N247 produces useful output in this same circuit at frequencies up through 50 Mc. These transistors may be used interchangeably in this instrument without circuit changes of any kind. The dial calibration remains accurate for either transistor.

### Construction

The entire instrument is housed in a "Flexi-Mount" case measuring 2⅛ by 3 by 5¼ inches. All parts are mounted in the upper section of the case as shown in the photographs, Figures 2 and 3. It is suggested that the case be drilled and cut in the following steps to insure proper fitting of the parts. Cut the meter mounting hole first. A 2⅜-inch square meter, such as the Simpson Model No. 1227, is recommended. The meter hole should be cut ⅛ inch in from one end of the case and the meter temporarily mounted. Cut a piece of 3/32-inch polystyrene about 1⅝ inches wide and 2¾ inches long and drill two ¼-inch holes at one end to fit over the meter binding posts. This strip will serve as a mounting board for the tuning capacitor and other small parts. Next, cut two discs from 1/16-inch-thick polystyrene for the dial. Sandwich the printed dial, shown at right, between the discs, and fasten the discs by means of two small screws to a bushing having a ¼-inch diameter hole. Drill and tap the bushing to receive these screws. Make two cuts in the front right-hand side of the case far enough apart to allow the tuning dial to protrude about ¼ inch. Bend the cut-out piece under and lay the dial in place. A similar cutout is also required for the cover section of the case. Bolt the tuning capacitor to its mounting strip so that its shaft engages the dial bushing, as shown in Figure 3. Next, cut a window in the top of the case for use in viewing the dial. A piece of thin wire may be fastened across the dial window to provide a hairline.

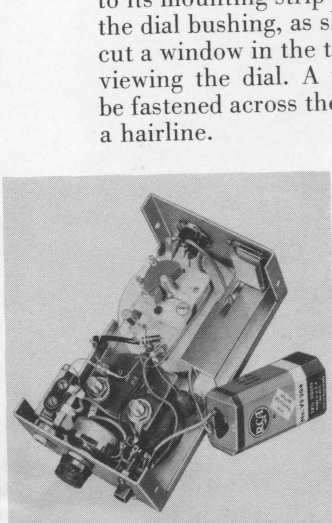
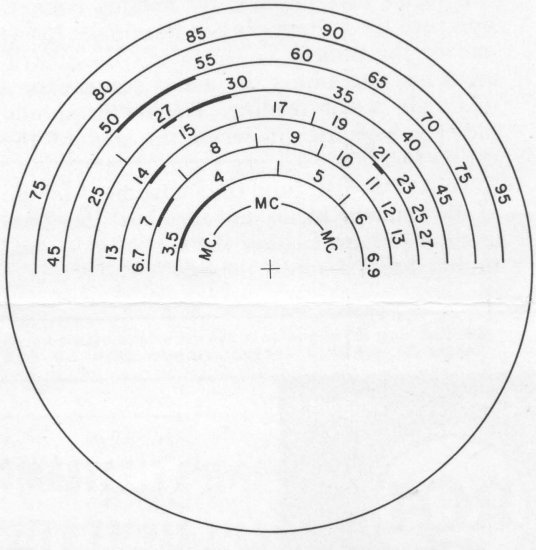


Figure 2: Bottom oblique right inside view of grid-dip meter showing parts layout. Battery has been removed to show battery mounting platform.

Mount the coil socket so that the rotor connection of the tuning capacitor contacts pin No. 1 of the socket, as shown in Figure 3. The meter control, phone jack, and switch are mounted at the rear of the case. Bend a ¾-inch-wide strip of metal to hold the battery as shown in Figure 2. Fasten one end of this strip to the front of the case and the other end to one of the meter mounting screws. A portion of the capacitor mounting strip should be cut away to make room for the battery. A folded strip of metal at the front of the case serves as a spring to hold the battery in place. The cover section of the "Flexi-Mount" box helps to secure the battery when the case is sealed.

Check to see that all parts fit into place and that the dial moves freely. Some minor




Here is the dial referred to in the text at left. Trim along the outer circumference of this dial and sandwich it between two plastic discs of the same diameter.

adjustments may be required. Use of washers and some judicious filing to alter the positions of the parts may be helpful.

**Wiring:** The instrument is now ready for wiring. It is suggested that parts be located as shown in the photographs. Wiring is not critical; however, for dial accuracy, the two heavy leads connecting the tuning capacitor and coil socket should be kept short, as shown in the photographs. The polystyrene strip supporting the tuning capacitor may be used as a mounting board and drilled to accept leads from small parts including those of the transistor.

**Coils:** Coils are constructed according to the table shown in Figure 1. Pins No. 3 and No. 4 on each of the two high-frequency coils

(45 to 78 and 74 to 97 Mc) should be connected with a jumper to short out resistor $R_3$. This connection automatically sets the emitter voltage at the proper value when either of the high-frequency coils is used. Pin No. 5 of the coil form should be used for the end of the coil furthest from the pins. This arrangement puts the "hot" end of the coil in the best operation position. Following initial tests and adjustments, the coils should be sprayed lightly with a clear plastic spray. A dot of paint at the end of each coil form, with matching dots on the case next to the dial window, provides color coding to indicate frequency range of the coil in use.

**Initial Tests and Adjustments:** Check the wiring carefully before installing the 13½-volt battery. Two small pins like those on the coil forms may be used for making connection with the battery plug-in terminals. Insert one of the plug-in coils, switch the instrument on, and adjust the meter control for a mid-scale meter reading. The meter should indicate a sharp dip when the end of the coil is touched.

To set the dial, tune the instrument to one of the amateur bands and zero-beat its signal in the receiver. Loosen the set-screw on the tuning dial and adjust the dial to the receiver frequency. Tighten the set-screw and check the other coils for accuracy. Increased dial accuracy may be obtained by spreading or compressing the turns on the coils. If the coils have been properly wound and the tuning capacitor mounted as described previously, dial accuracy approaches ±2%.

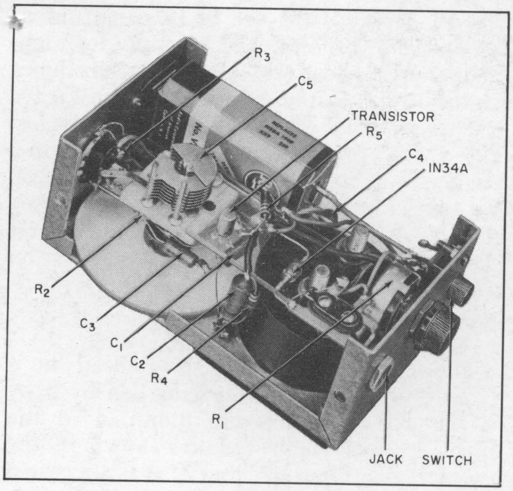



Figure 3: Bottom oblique left inside view of grid-dip meter showing parts layout and tuning capacitor mounting. Note cutout necessary to clear tuning dial.



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Harvey Slovik, Editor
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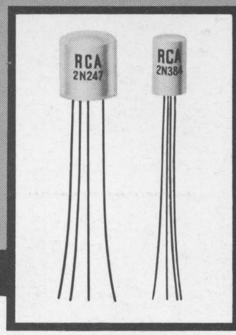
VOL. XVIII, No. 3  JUNE, 1958


# A TRANSISTORIZED GRID-DIP METER

## Part II: Operation and Use

By Clarence A. West, W2IYG

RCA Electron Tube Division, Harrison, N. J.

W2IYG's two-part feature article began in the April, 1958, issue of HAM TIPS, which contained a description of the transistorized grid-dip meter designed and constructed by the author along with details of its construction. If you missed Part I, ask your local RCA distributor for a copy.

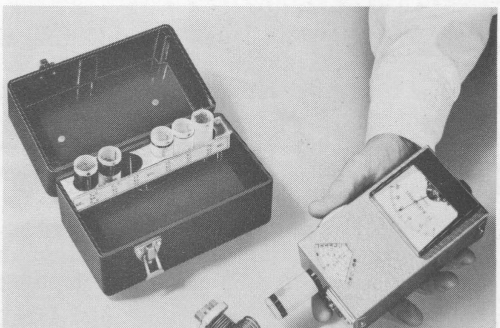
The transistorized grid-dip meter described in this article was designed primarily for determining the resonant frequency of tuned circuits quickly and with accuracy. To use the instrument for this application, estimate the approximate resonant frequency of the unknown tuned circuit and insert a coil having suitable frequency range. Switch on the instrument, adjust the meter control knob for a meter reading of about half-scale, and then tightly couple the coil to the unknown tuned circuit.

Keep both coils in the same plane for maximum coupling. Starting at one end of the tuning dial, rotate the dial slowly until a *pronounced* dip in meter reading occurs, then back the instrument off and tune through resonance again. Use loose coupling for accurate measurements, as indicated by a very small dip in meter reading.

Be sure the transmitter plate supply is turned off when "dipping" tank circuits in transmitters. There is danger of shock if this precaution is not observed.

The instrument may be used for many other applications including:

**Signal Generator**—To check the alignment of a receiver, tune the receiver, with AVC on, to a frequency at which no signals are present. Locate the instrument a few feet from the receiver at some convenient point along the receiver transmission line and tune to the receiver frequency as indicated by an "S" meter reading. Because there is no need to disconnect the line from the receiver, an accurate alignment check is provided with the



W2IYG's transistorized grid-dip meter being used to measure the frequency of a tuned circuit. (Note instrument carrying case with coil-storage rack. The case is made from two plastic cases, such as Allied 86P286, fastened together with a small set of hinges. A handle and lock complete the case. The coil storage rack is cut from a thin sheet of aluminum and riveted or screwed into place. Coils and dial window are color coded to indicate frequency range of coil in use.)

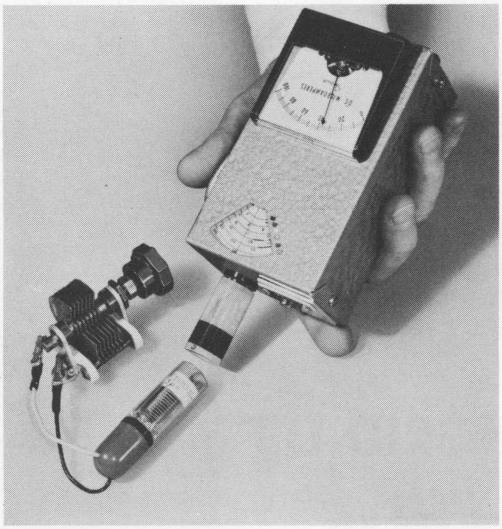


Figure 1: Use of author's grid-dip meter to measure value of an unknown capacitor. The standard inductance consists of 15¾ turns of B&W Miniductor #3003 (½-inch diameter, 16 TPI) enclosed in an Amphenol coil form type 24-5H. Note use of adapter with clip leads for connection to unknown capacitor.

existing antenna system and receiving conditions.

**Field Strength Meter**—Set the operating switch to the "off" position and connect a short length of wire to coil socket pin No. 2. *No coil is needed for this application* because the short length of wire serves as the pickup. The instrument can now be used to indicate rf voltages up through the VHF region. In this application, only the indicator portion of the instrument is utilized.

As an example of its use in loading an rf amplifier, couple the instrument loosely to the antenna transmission line by means of a short length of wire. Keep the instrument and pickup wire far enough away from the final amplifier tank to prevent excessive rf pickup from the tank itself. Tune and proceed to load the amplifier, observing the field strength meter. With increased loading, both the field strength meter and plate current meter of the amplifier will indicate increased readings. For maximum output, coupling should be increased until the field-strength-meter reading reaches its peak. With overcoupling, the plate current will continue to rise and the field-strength-meter reading will drop. Adjust the coupling to maintain the highest field-strength reading with the lowest plate current reading. Be sure to maintain resonance of the amplifier.

**Monitor**—Because the battery in the instrument is disconnected for *field-strength* use, the instrument may be placed conveniently anywhere in the shack and utilized as a visual monitor of all transmissions. Use a length of wire, as described previously, to serve as an rf pickup. A pair of high-impedance headphones plugged into the jack can be used for monitoring an amplitude-modulated signal.

**Neutralizing Indicator** — Using the instrument as a field-strength meter, couple the pickup wire to the plate tank coil of the amplifier stage to be neutralized. Plate and screen-grid voltages must be off, but full drive applied to the input circuit. Tune the plate tank circuit to resonance as indicated by maximum reading on the field strength meter. Adjust the neutralizing capacitor for minimum reading. If initial meter reading is too low, increase coupling to the tank by wrapping the pickup wire around the tank coil or by forming a single- or several-turn loop and returning the free end of the pickup wire to the instrument case or coil pin No. 4. Adjust the neutralizing capacitor for minimum rf indication.

**Wavemeter**—If it is desired to utilize this instrument as a wavemeter, a DPST switch should be used in place of the SPST switch shown in the circuit diagram in Part I. Wire the switch to open both the base circuit at the transistor and battery circuit when the switch is in the "off" position.

To check the output frequency of a trans-

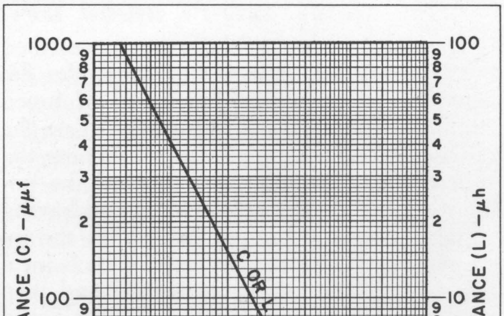



Figure 2: Chart for determining unknown values of L and C in the range 1 to 100 μh and 10 to 1000 μμf using an 18 μμf capacitor and a 1.3 μh inductance as standards.

mitter, insert a plug-in coil which will provide the instrument with the desired tuning range. The operate switch should be in the "off" position. Turn on the transmitter and *loosely* couple the wavemeter to the desired tank circuit. Tune the wavemeter for maximum meter reading. The tuning dial will indicate the output frequency of this stage.

**Measurement of Capacitance or Inductance Values**—The value of a capacitor in the range of 10 to 1000 $\mu\mu$f can be measured as follows: Connect the unknown capacitor across a 1.3 $\mu$h standard coil as shown in Figure 1. Starting with the lowest-frequency-range coil plugged into the instrument, de-

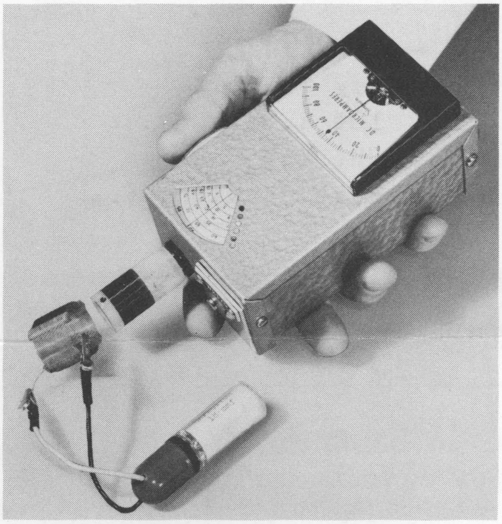


Figure 3: Use of grid-dip meter to measure an unknown inductance. A standard capacitor of 18 $\mu\mu$f is utilized. This standard capacitor is mounted inside an Amphenol type 24-5H coil form.

termine the resonant frequency of the standard coil and the unknown capacitor. When the resonant frequency is found, utilize the chart shown in Figure 2 to determine the value of the unknown capacitor. A capacitor of 100 $\mu\mu$f, for example, will resonate with the test coil at a frequency of 12.2 Mc.

The value of an inductance in the range 1 to 100 $\mu$h can be accomplished in a similar manner, except a standard capacitor of 18 $\mu\mu$f is utilized. Connect the standard capacitor across the unknown inductance, as shown in Figure 3, and determine the resonant frequency of this circuit. Utilizing the chart, determine the value of the unknown inductance. An inductance of 5 $\mu$h, for example, will resonate with the standard capacitor at a frequency of 17.5 Mc.

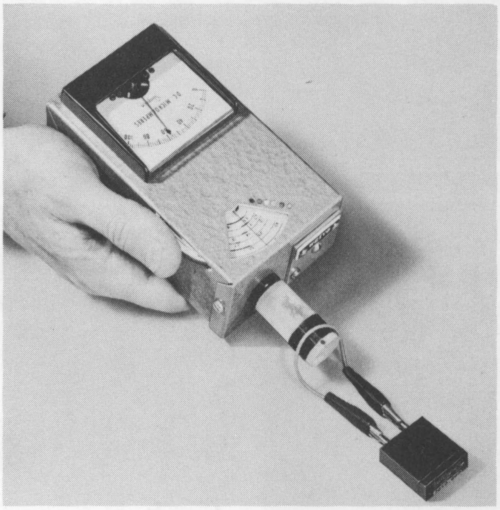
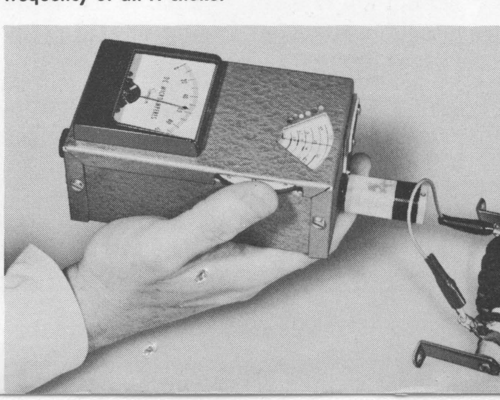


Figure 4: Use of grid-dip meter to test a quartz crystal.

**Testing Quartz Crystals**—The frequency of a quartz crystal may be determined by connecting a short length of wire to each of the crystal holder pins to form a small loop (see Figure 4). Couple the grid-dip meter coil tightly by inserting the coil inside the loop of wire. Tune the instrument slowly until a dip occurs, then loosen the coupling and re-"dip" the circuit. Read the crystal frequency on the tuning dial. This test also indicates activity of the crystal. The meter will not dip with an inactive crystal.

**Checking RF Chokes for Self-Resonance**—It is important that rf chokes used in parallel or shunt fed circuits be free of series resonance over the operating frequency range of the circuit to prevent their burning out. The popular pi-tank circuit is such an example in which the rf choke is shunted across the full rf output of the tube. To test the choke for series resonance, short-circuit the choke and determine its resonance frequencies with the grid-dip meter, as shown in Figure 5.

Figure 5: Use of grid-dip meter to test series resonant frequency of an rf choke.



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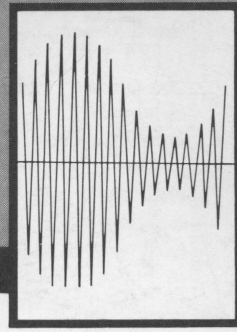
- Provide for adequate ventilation around tube to prevent tube and circuit damage caused by overheating.
- Keep shiny shielding surfaces away from tube to prevent heat reflection back into tube.
- Design circuits around tube to use lowest possible value of resistance in grid circuit and screen circuit.
- In high frequency service, operate tube under load conditions such that maximum rated plate current flows at the plate voltage which will give maximum rated input.
- Have overload protection in plate and screen circuits to protect tube in the event of driver failure.
- See that plate shows no color when operated at full ratings (CCS or ICAS conditions).
- Reduce B+ or insert additional screen resistance when tuning under no-load conditions to prevent exceeding grid-No. 2 input rating.
- Maintain tuning and loading adjustments precisely so that tube will not be subjected to excessive overload. The 6146 is a high-gain, high-perveance tube and can be more easily overloaded through circuit misadjustments than older types not having such features.
- Use adequate grid drive, keeping within maximum grid-current and screen dissipation ratings of tube. Too little grid drive can cause high plate dissipation.
- Make connections to plate with flexible lead to prevent strain on cap seal.
- Operate 6146 within RCA ratings as shown in technical bulletin available on request from RCA Commercial Engineering, Harrison, N. J.

# HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. XVIII, No. 4


SEPT.-OCT., 1958



# WHICH IS WHAT?

## A Review of Some Modern Amplitude-Modulation Systems

**by Kenneth W. Uhler***

Single sideband, synchronous detection, compatible single sideband! These and many other similar phrases appear in many of today's publications. But too often the advantages claimed for one of these systems in the article you are currently reading conflict with the claims made for another system featured in the article you read last week. This seeming confusion leaves the reader with the question: "Which is what?" Hence, this article – intended as a review of the basic systems in the hope that it will lead to a better understanding of the published material.

Before a comparison of amplitude-modulation systems is made, however, some of the terms used in this article should be defined. The symbols are derived from the terms used and refer to frequencies, not magnitudes.

The radio frequency to be modulated is referred to as the carrier and the symbol is $f_c$. Similarly, this article is concerned with radiotelephony, where the modulating signal is the voice, and the symbol used is $f_v$.

Amplitude modulation can be defined as the process of varying the amplitude of a carrier at an audio rate. The result is that two new frequencies, $(f_c+f_v)$ and $(f_c-f_v)$, are produced.

For example, if the carrier frequency is 14 Mc, and it is modulated by an audio frequency of 1000 cycles:

14,000,000 modulated with 1000 will give:
$(f_c)$ $(f_v)$

14,001,000 and 14,000,000 and 13,999,000
$(f_c+f_v)$ $(f_c)$ $(f_c-f_v)$

The sum of the two frequencies $(f_c+f_v)$ is referred to as the upper sideband and the difference between the two frequencies $(f_c-f_v)$ is referred to as the lower sideband.

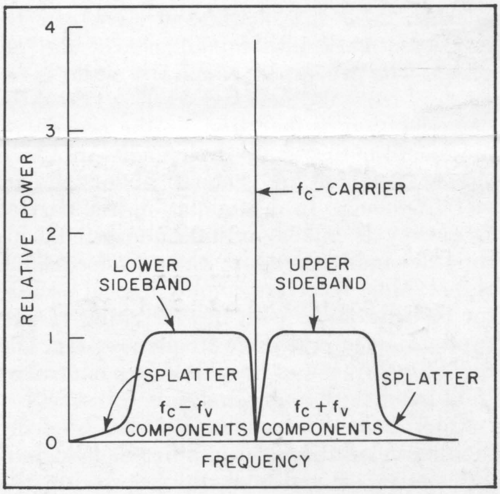



**Figure 1: amplitude modulation.**

### AM (Both Sidebands and Carrier)

In the example of amplitude modulation given above, the modulated signal consists of

*Mr. Uhler is an engineering leader in the Industrial Tube Applications Laboratory of the RCA Electron Tube Division, Harrison, N. J. He is also a Senior Member of the Institute of Radio Engineers and a member of the IRE Professional Groups on Vehicular Communications and Communications System.

three frequencies: the lower sideband ($f_c - f_v$), the carrier ($f_c$), and the upper sideband ($f_c + f_v$). Figure 1 illustrates a frequency versus power curve for AM. The width of the sideband is dependent on the highest audio frequency used to modulate the carrier.

One of the common methods of obtaining amplitude modulation utilizes the fact that a power tube when operated Class C has a generally linear output for wide variations in plate voltage. Modulation is accomplished by inserting the audio signal in series with the plate of the tube.

No practical modulating system is without some non-linearity, and non-linearity, however small, leads to the generation of some unwanted frequencies. Because the plate tank has a relatively low Q when loaded and, therefore, relatively poor selectivity, all the unwanted frequencies generated are not filtered out. When these unwanted signals appear outside of the desired band, they can create very undesirable interference.

The AM system is not complete until we consider how the modulated wave can be translated back into intelligence at the receiver. The process by which the audio is recovered from the radiated wave is known as demodulation or detection. In the process of modulation, the audio frequencies produce sidebands which are centered about the carrier frequency. In demodulation, the carrier frequency is mixed or intermodulated with the sidebands to produce an audio frequency signal. Most receivers employ a local oscillator to heterodyne with the incoming rf and produce an intermediate frequency (if). The fixed-tuned if stages provide easier control of both bandwidth and gain.

One of the most common methods of demodulation utilizes the unidirectional characteristics of a diode which provide the non-linearity needed to intermodulate the carrier with the sidebands. One product of the intermodulation is the audio frequency. The unwanted sideband, carrier, and higher-frequency products are filtered out in simple RC circuits.

The diode demodulator has two distinct disadvantages. First, it has no gain, and the desired signal is usually attenuated 10% to 20% because rf filtering is required. Second, the desired modulation component becomes distorted at low signal levels and high percentages of modulation.

The complete AM system is subject to another commonly experienced phenomenon known as selective fading. Briefly, selective fading is a reduction in signal strength of a part of the band of frequencies transmitted. It can affect the amplitude and/or phase relationship between the carrier and either or both of the sidebands. This distortion in ordinary receivers often results in a significant loss of intelligibility.

The primary advantages of AM systems, as described, lie in their simplicity and low cost. Moreover, many practical techniques have been developed which greatly enhance the usefulness of AM. Improved bandwidth control and oscillator stability, better noise limiting and blanking circuits, and heterodyne detectors are all widely used in new receiver designs. The heterodyne detector, for example, produces much lower-order distortion for small-signal inputs than any of the simpler diode circuits, and can handle high percentages of modulation. This detector mixes a local oscillator signal with the radio frequency or intermediate frequency to produce an amplified audio signal.

Speech clipper and modulator design in the transmitter also can be greatly improved, and at only small additional cost and complexity. In comparing "new" systems to "ordinary" AM, one should be careful to determine how much of the advantage offered by the system comes from improvements that could be added to any system.

### DSB (Both Sidebands, No Carrier)

"Double sideband" is also referred to as synchronous AM. The term "synchronous AM" comes from a method used to detect amplitude modulation. Basically, this method uses a heterodyne detector which demodulates directly to audio by mixing the modulated rf with a local oscillator signal. The local oscillator signal must be synchronized (in phase) with the original carrier to prevent unwanted phase distortion.

One such proposed system demodulates in two simultaneous heterodyne detectors. The local oscillator signal fed to one of them is phase shifted 90 degrees, so that the audio-output signal from this detector is zero.

When the local oscillator is phase locked (exactly in phase) to the original carrier frequency, the phase-shifted heterodyne output will remain zero. If the local oscillator is not in exact phase with the original carrier, the shifted detector will have an audio output proportional to the phase difference. This signal is used to provide a correction voltage for an automatic-frequency-control circuit. The frequency of the local oscillator is con-

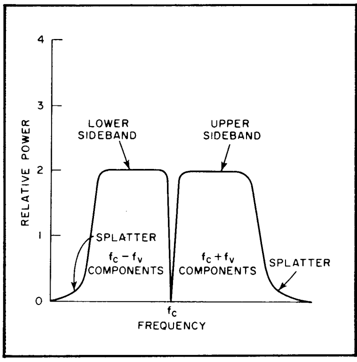



Figure 2: double sideband.

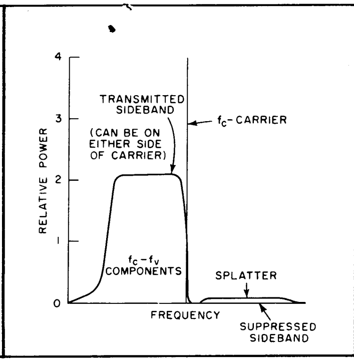



Figure 3: compatible SSB.

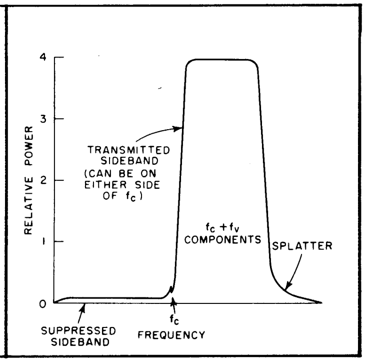



Figure 4: single sideband.

trolled at the apparent carrier frequency, reducing the effect of any selective fading present.

The principal advantages of this system come from the fact that no carrier is needed and the single receiver oscillator is frequency controlled. Of all the systems, synchronous AM is the least affected by selective fading.

Figure 2, drawn to the same scale as the AM diagram in Figure 1, points out the increased sideband power available for DSB operation without taking into account possible transmitter redesign. Balanced modulation in the transmitter will reduce the carrier level at least 30 db without special circuits of any kind. Balanced modulation is usually accomplished by using a push-pull final, which retains one of the advantages of AM in that it allows plate modulation of the final.

Two distinct advantages are inherent in the double-sideband system: 1) Reduction of the carrier eliminates the most annoying source of a continuous beat-frequency whistle interference produced by a co-channel station which reduces signal intelligibility and produces operator fatigue to a far greater degree than the "monkey chatter" of sideband cross-modulation products. 2) The final power amplifier is generally operated Class C in a balanced circuit so that rf power is produced only when modulation is present.

### Compatible SSB (Single Sideband With Carrier)

The compatible single sideband system—currently being used by the "Voice of America" and WMGM—can be received on the present ordinary diode detector receivers. Balanced modulation is used to suppress the carrier, as in synchronous AM. One sideband is then filtered out and a controlled amount of carrier reinserted.

Compatible SSB can be represented as shown in Figure 3. Either sideband can be used. This system is subject to selective fading much in the same manner as conventional amplitude modulation, and is somewhat more susceptible to fading than AM and synchronous AM because the single sideband does not afford the redundancy of the double sideband. The advantages of this system are very important in applications like the "Voice of America" and other ground-to-fixed-station systems because of the following characteristics:

(1) Half the normal AM bandwidth.

(2) Compatible with existing receiving equipment.

(3) Allows increased efficiency in high-power transmitter design.

### SSB (Single Sideband, No Carrier)

SSB goes all the way and transmits only one sideband, as shown in Figure 4. The lack of a carrier eliminates the whistle type of co-channel interference.

The bandwidth is the same as the bandwidth of the modulating frequency. The signals handled in the transmitter final are entirely modulation components. RMS power ratings become somewhat meaningless because voice modulation has such a complex waveform. For this reason, SSB finals are usually rated in terms of peak power capability. Balanced modulators are used to reduce the carrier at least 30 db. Phase networks, or filters, can be used to remove the unwanted sideband and further reduce the carrier.

Somewhat more complexity results from the low frequency used. Heterodyne circuits must be used to bring the signal frequency up to the rf region. Non-linear frequency multipliers, such as harmonic generator and

doublers, are not suitable because they would produce a high percentage of unwanted signals and distortion. Such circuits would also multiply the voice frequencies. This result would require complex frequency-divider circuits in the receiver.

The driver stages and final amplifier must be linear for the same reason. Efficiency of the final amplifier is considerably higher due to the fact that no carrier power is involved and the final can be designed to handle much greater peak power without exceeding the dissipation ratings. Because the zero signal condition exists until modulation is present, two-way single-channel communications are simplified (simplex operation).

The main disadvantages of the SSB system stem from the fact that demodulation must be accomplished by the addition of a demodulating signal at the receiver (often referred to as reinserting the carrier). Variations in the frequency of this injected signal will cause distortion of the voice frequencies that sound like a variable-speed phonograph. It is my personal opinion—through listening—that although this distortion is objectionable from a theoretical standpoint, it actually results in very little loss in intelligibility over a $\pm 150$ cycle range. Critical applications are usually governed by a $\pm 50$ cps maximum. The interference from an adjacent channel results in variable-pitch "monkey chatter" which can be tolerated even at quite high levels.

Selective fading becomes just plain fading in the case of only one sideband. The ability to select sidebands could provide the necessary redundancy to overcome this effect, but it would double the bandwidth.

The disadvantages of SSB are: (1) increased complexity, (2) tight frequency-drift specifications, (3) non-compatibility with existing equipment, and (4) both the transmitter and the receiver have tight linearity requirements. Cost is not always a factor. For equipments designed to produce the same degree of intelligibility between any two points, savings in power supply and tube cost make it entirely possible to build SSB equipment in the same price range as the comparable AM equipment.

The advantages of SSB, other than those associated with the improved circuitry, are: (1) narrow bandwidth and (2) improved co-channel and adjacent channel operation (elimination of carrier whistle). Although these advantages are small in number, they are large in their importance to commercial and military communications.



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**RCA HAM TIPS is published by the RCA Electron Tube Division, Harrison, N. J. It is available free of charge from RCA distributors.**

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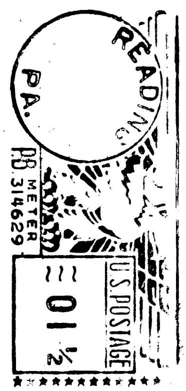


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